Hybrid low-dimensional limiting state of charge estimator for multi-cell lithium-ion batteries

Mira Khalil*[1], Romain Postoyan[2], Stéphane Rael[3], and Dragan Nešić[4]

[1]Université de Lorraine – Université de Lorraine - CRAN CNRS UMR 7039, Groupe de Recherche en Électrotechnique et Electronique de Nancy (GREEN) – France
[2]Universite de Lorraine – Université de Lorraine - CRAN CNRS UMR 7039 – France
[3]Université de Lorraine – Groupe de Recherche en Électrotechnique et Electronique de Nancy (GREEN) – France
[4]University of Melbourne – Australie

Résumé

The state of charge (SOC) of lithium-ion batteries needs to be accurately estimated for safety and reliability purposes. For battery packs made of multiple cells, it is not always feasible to design one SOC estimator per cell due to limited computational resources. Hence, instead, we rely on estimates of the minimum and the maximum states of charge (SOC). The challenge is that the cells having minimum and maximum SOC typically change over time. In this context, we present a low-dimensional hybrid estimator of the minimum (maximum) SOC, whose convergence is analytically guaranteed. We consider for this purpose a battery consisting of cells interconnected in series, which we model by an electric equivalent circuit model. We then present the hybrid estimator, which runs an observer designed for a single cell selected by a switching-like logic mechanism. We establish a practical exponential stability property for the estimation error on the minimum SOC thereby guaranteeing the ability of the hybrid scheme to generate accurate estimates of the minimum (maximum) SOC. The analysis relies on non-smooth hybrid Lyapunov techniques. A numerical illustration is provided to showcase the relevance of the proposed approach. This work is submitted to IEEE Conference on Decision and Control 2024.

*Intervenant